RESEARCH NOTES

Rocky Mountain Forest and Range Experiment Station
Raymond Price, Director

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SEQUENTIAL SAMPLING OF ENGELMANN SPRUCE BEETLE INFESTATIONS IN STANDING TREES

by
Fred B. Knight, Entomologist

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Procedures have been developed for sampling brood densities of the Engelmann spruce beetle (Dendroctonus engelmanni Hopk.) in standing trees to determine infestation trends.[1] The procedure consists of the removal of two 6- by 6-inch bark samples from each of 25 trees. All living spruce beetles in and beneath these bark samples are counted. The samples are removed from the bole between 4 and 7 feet above the ground; one from the north and one from the south side of the tree.

Sampling for evaluation of infestation trend is confined to two periods in the life cycle of the insect. The first of these is in late June of the year following attack by the beetles. At this time the progeny are in the larval stage. The second is in late August or early September of the same year. At this time most of the progeny are callow adults. This latter sampling must be done before the adult beetles emerge for hibernation.

By the use of procedures described by Bliss and Fisher[2] the sampling data were compared with the negative binomial distribution.[1] A good fit was found for three classes of infestation - - decreasing, static, and increasing.

The currently used sampling procedure utilizes a fixed number of samples. This is generally a good procedure. However, sometimes more samples are taken than needed and at other times additional samples are needed for reliable predictions.

Sequential sampling is a method by which populations may be classified into categories by using a flexible sample size. With this procedure, sample units are examined in sequence until the cumulative counts fall into one of the classes distinguished by previously determined limits. When brood densities are very low or very high the amount of sampling required is much less than that required by a fixed sampling procedure. The procedures for computing sequential sampling plans for the negative binomial distribution are described by Waters.[3]

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1 Knight, F. B. Measurement of Engelmann spruce beetle populations. Ecology 41: 249-252, illus. 1960.

2 Bliss, C. I., and Fisher, R. A. Fitting the negative binomial distribution to biological data and note on the efficient fitting of the negative binomial. Biometrics 9: 176-200. 1953.

3 Waters, W. E. Sequential sampling in forest insect surveys. Forest Sci. 1: 68-79, illus. 1955.

In the following plans the class limits may seem low to the reader. This is due to the differential survival in the tree bole.[1] Beetle survival in the bole is much greater below the sampling location (4 to 7 feet above ground). Because of this, the numbers surviving at the sampling location and above need not be so large as expected, to indicate a static or increasing infestation.

June Sampling Plan

Sampling in June is done to determine whether control work is needed immediately. For this purpose only two categories are necessary: (1) Not treatable--in this case the infestation is expected to decrease; (2) Treatable--in this case the infestation is expected to remain static or increase.

The class limits used in computing the sequential table (table 1) are:

Not treatable = 4 beetles or less per 6- by 6-inch sample
Treatable = 5 beetles or more per 6- by 6-inch sample

The probability levels (α and β) are 10 percent and the negative binomial constant (k) is 0.8364.

Table 1.--Sequential sampling plan for Engelmann spruce beetle infestations in standing trees for determining treatability (June counts)

Number of samples examined	Cumulative number of beetles		Number of samples examined	Cumulative number of beetles	
	Not treatable	Treatable		Not treatable	Treatable
20	27	151	52	170	294
22	36	160	54	179	303
24	45	169	56	188	312
26	54	178	58	197	321
28	63	187	60	205	330
30	71	196	62	214	339
32	80	205	64	223	348
34	89	214	66	232	357
36	98	223	68	241	366
38	107	232	70	250	374
40	116	241	72	259	383
42	125	250	74	268	392
44	134	259	76	277	401
46	143	268	78	286	410
48	152	277	80	294	419
50	161	285			

Twenty samples are the minimum presented in the table. An infestation could be classified with a smaller number of samples but from experience the author and his coworkers believe that at no time should counts from less than 20 samples be obtained (10 trees). Also, an infestation might not be classified after counts from 80 samples are accumulated. In fact, such an infestation could require the sampling of many more trees. If no decision can be made by using the table after 80 samples are removed, the infestation should be

classed treatable. Only the even sample numbers are included in the table; the recorder should always remove two samples from each tree.

The procedure in sampling is to cumulate the total number of live beetles until this total is less than the lower or more than the higher of the two numbers shown in the table for a specified number of samples examined. For example, if after totaling the count from 42 samples the sum is less than 125 live beetles (larvae), the infestation is classed not treatable.

August-September Sampling Plan

Sampling in late August or early September is done for a somewhat different purpose. It is usually too late to carry out chemical control work or logging on the particular infested trees, but not too late to use trap trees. The evaluation at this time is for predicting the seriousness of the infestation in terms of the number of newly infested trees that will result from the flight of beetles in the following spring and summer. For this purpose the infestation categories are:

(1) Increasing--the emerging beetles will kill more trees than presently infested;
(2) Static--they will kill about the same number; and
(3) Decreasing--they will kill fewer trees.

The class limits used in computing the sequential table (table 2) are:

Decision 1 -- Increasing = 4.5 or more beetles per 6- by 6-inch sample
Static = 3.5 or less beetles per 6- by 6-inch sample

Decision 2-- Static = 2.5 or more beetles per 6- by 6-inch sample
Decreasing = 1.5 or less beetles per 6- by 6-inch sample

The probability levels (α and β) are 10 percent and the negative binomial constant (k) is 0.6957.

Table 2 differs from table 1 in the number of decisions. After 38 samples are accumulated, one of three decisions is possible. If the total is less than the number in the decreasing column, the infestation is classed decreasing; if it is more than the first number of the static column and less than the second number, the infestation is static; and if the total is greater than the number in the increasing column, the infestation is classed increasing. After 80 samples are removed, a no-decision situation is possible; the cumulative number of beetles may be between the columns. In such cases the infestations would be classed static or increasing depending upon the situation.

Discussion

The two sequential sampling plans presented in this note provide a systematic and efficient means for evaluating the trend of Engelmann spruce beetle infestations. They are ready for immediate field use. As further data are accumulated, the class limits may be more precisely defined.

One problem in evaluating Engelmann spruce beetle infestations must always be kept in mind when using these tables, namely, the beetle population that may be present in wind-felled trees and logging debris. The determination of treatability and the prediction of infestation trend as obtained from standing trees applies only to the populations in standing trees. When very low populations of beetles survive in standing trees, a bumper crop may survive in cull logs nearby. This difference is caused by woodpeckers, which are ineffective against spruce beetle populations in down material. Infestations in cull material and wind-felled trees must be evaluated separately.

Table 2.--Sequential sampling plan for Engelmann spruce beetle infestations in standing trees for predicting infestation trend (August-September counts)

Number of samples examined	Cumulative number of beetles		
	Decreasing	Static	Increasing
20	22		137
22	26		145
24	30		153
26	34		161
28	38		169
30	42		177
32	46		185
34	50		193
36	54		201
38	58	89 to 91	209
40	61	93 to 99	217
42	65	97 to 107	225
44	69	101 to 115	233
46	73	105 to 123	241
48	77	109 to 131	249
50	80	112 to 139	256
52	84	116 to 147	264
54	88	120 to 155	272
56	92	124 to 163	280
58	96	128 to 171	288
60	99	132 to 179	296
62	103	136 to 187	304
64	107	140 to 195	312
66	111	144 to 203	320
68	115	148 to 211	328
70	119	151 to 219	335
72	123	155 to 227	343
74	127	159 to 235	351
76	131	163 to 243	359
78	135	167 to 251	367
80	138	170 to 258	375

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